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(54) Title: SPRING AND ENDOSCOPE EQUIPPED WITH SUCH A SPRING

(57) Abstract: The invention relates to a spring comprising a chain of a series of closed, flexible elements, of which always a pair of two adjacent elements from the series are partly connected with each other. In a first embodiment, each pair of two adjacent elements is coupled at a predetermined, in relation to a neighbouring pair of elements, different position. In a second embodiment each pair of two adjacent elements is coupled at a predetermined, and with respect to a neighbouring pair of elements, identical position.

Spring and endoscope equipped with such a spring

The invention relates to a spring.

Springs are known in various forms. The spiral spring, for example, is used for many purposes. With such a spring it is possible to connect two elements of a device with each other. A disadvantage of the known spring is, however, that the connection is omnidirectionally flexible, which means that additional measures have to be taken if the connection between two elements of a device is desired to be realized by means of a conventional spring such as to be flexible in a predetermined direction and rigid in another predetermined direction.

The object of the invention is primarily to provide a spring which on the one hand makes it possible to flexibly connect different devices or elements of a device, while on the other hand they can be coupled by the same spring to be torsion-proof.

To this end the spring according to the invention is characterized by a chain of a series of closed, flexible elements, of which always a pair of two adjacent elements from the series are partly connected with each other. By means of this very elegant and surprisingly simple design it is thus nevertheless possible to combine two apparently intrinsically incompatible characteristics of a spring. The spring according to the invention allows devices that are connected with the spring to be flexibly coupled in the longitudinal direction of the spring. On the other hand, though, the connection between said devices is torsion-proof due to the spring exhibiting a high degree of torsional stiffness.

A first preferred embodiment of the spring according to the invention is characterized in that each pair of two adjacent elements in the series of elements is coupled at a predetermined and in relation to a neighbouring pair, different position. In this embodiment the flex-

ural stiffness of the spring is distributed substantially uniformly in all directions transversely to the longitudinal direction of the spring, while retaining the torsional stiffness mentioned earlier. With the aid of such a spring it is simple to couple two rotatable axis ends that are positioned at an angle.

In another preferred embodiment, the spring is characterized in that each pair of two adjacent elements in the series of elements is coupled at a predetermined, and with respect to a neighbouring pair of elements, identical position. In this way the spring is provided with a direction-biased flexural stiffness such that it exhibits very little flexural stiffness when bending forward and backward, whereas the spring exhibits great flexural stiffness when bending sideways. In this embodiment also the spring retains a high degree of torsional stiffness.

Especially this latter embodiment is very advantageous in certain applications as will be explained hereafter. The first advantageous application is to be found in the field of endoscopy. Other suitable applications of the spring according to the invention relate to drilling at an angle, as is sometimes necessary with earth formations. Also driving shafts that are to be coupled at an angle can be applied conveniently when combined with the spring according to the invention.

The spring according to the invention may be conveniently realized by fabricating it from a rod or tube of spring steel, with regularly distributed grooves being applied over the surface of the rod or tube.

As indicated above, the invention is also embodied in the application of the spring according to the invention in an endoscope.

A conventional endoscope comprises an endoscope shaft, proximally positioned control means, and a distally positioned camera. A difficulty with this endoscope is that the adjustment of the camera via the control means poses several problems.

The traditional endoscope is formed like a straight, rigid inspection tube with the lens looking ahead. Around the inspection tube light conductors are provided to illuminate the object to be inspected. The image obtained by means of such an endoscope is projected on a monitor to provide a surgeon with image data, while keeping the invasiveness of the surgery to a minimum. With this way of image forming, however, problems arise with respect to the perception of distances and movements perpendicular to the focal plane.

A first problem is that the surgeon accommodates in relation to the image provided by the monitor and not in relation to the actual objects. Consequently, perception of depth is a problem. Another problem is, that although the light source for the illumination mounted around the lens provides a clear image, it is disadvantageous with respect to the perception of depth because of the absence of shadows.

Yet another problem is that there is no movement parallax as a source of information with regard to depth. The movement potential of the traditional endoscope is limited due to the fact that when in use, it is inserted through a confined incision into the body of the patient, so that the number of degrees of freedom of movement the endoscope can use are limited to four of a possible six. It is therefore impossible to observe the anatomical structure from different sides while maintaining a focused image of what is being observed.

The limitations that are inherent to the known endoscope prevent a wide application of minimally invasive surgery, and demand in any case an expensive, intensive and lengthy training of the surgeon carrying out the minimally invasive surgery. A further disadvantage of the endoscope wherein the lens is mounted in the extended direction of the inspection tube is that its application impedes the operation as such. The endoscope is operated by an assistant who enters into the working space of the surgeon. In order to solve this problem, it is possible to

use endoscopes whose lens is mounted at an angle of 90° in relation to the inspection tube. The endoscope may then be inserted into the body of the patient at a position not impeding the surgeon. The drawback of such an endoscope is, however, that movement of the endoscope for the purpose of allowing further observation of the subject of examination results in a complicated image rotation on the monitor, making it more difficult to interpret the image provided with the 90° endoscope. Due to the fact that the incision point through which the endoscope is inserted is stationery, zooming in on the subject of examination by bringing the lens closer simultaneously involves a rotation of the endoscope, which means that the angle under which the subject of examination is being observed, changes with zooming in.

These problems may be effectively avoided by embodying the endoscope such that the camera is coupled with the endoscope shaft via a spring of the kind proposed by the invention, and that at least one traction wire extends through the endoscope shaft and is connected for one thing with the control means, and for another thing with the distal end of the spring. In this way the mechanically determined orientation of the camera with respect to the shaft and the control means is very good, the camera being able to precisely follow the position dictated by the control means. As control means it is possible to apply, for example, a control handle.

The term 'traction wire' is understood to denote an element that is preferably at least partly flexible, able to transmit a tensile force and/or pushing force. Examples include wires or cables of any type of material, such as plastic and metal, having sufficient tensile strength. It is also possible to use traction wires made of SMA material (SMA: Shape Memory Alloy).

Advantageously the spring is embodied such that each of the elements has a central opening, which is defined by the rim of the element. The series of central openings of the elements forms a conduit through which

wiring of the camera and optionally glass fibres for illumination may be passed.

For operating the camera with the control handle it is useful if feed-through openings are provided in the rim of the elements, that are suitable for a traction wire to be passed through.

A spring that may be realized at relatively low-cost and simply, and that serves the purpose of the invention, is characterized in that the elements are rings of which at least one is completely flat, and that adjacent to said flat ring there is at least one ring comprising at least one first bent rim portion coupled with the flat ring.

The spring is further preferably embodied such that the ring adjacent the flat ring, and having the first bent rim portion, has a second bent rim portion diametrically opposite the first bent rim portion of the ring, and that this second bent rim portion of the ring is coupled with a bent rim portion of an identically formed further ring.

The endoscope is preferably provided with at least three traction wires by means of which a 360° rotation of the control handle results in a reciprocal 360° rotation of the distal end of the spring. According to a further preferred embodiment, the endoscope is provided with four traction wires, so that an (even) better control is possible.

It is further favourable to embody the endoscope such that the distal end of the endoscope shaft is provided with a first spring according to the invention, to which the camera is attached. In accordance with a further embodiment, the endoscope shaft is provided at the proximal end with a second spring according to the invention. The control handle rests on the second spring's proximal end facing away from the endoscope shaft. Preferably a sliding element located in the control handle is connected with the distally positioned camera by means of traction wires, while a compensating spring with a sufficient

spring force, exerts a force on the sliding elements to ensure that in a non-operational position, the first and second spring are compressed.

According to a further favourable embodiment, the springs consist of a plurality of spring assemblies, each consisting of a plurality of elements. Each assembly comprises, for example, two terminal flat rings and a plurality of intermediate rings with bent rims, as explained above. For example, an assembly consists of a total of six elements: two terminal flat rings and four intermediate rings with bent rims. If four traction wires are provided, each at identical distances of rotation (i.e. over 90°) the spring assemblies are each time effectively rotated over 90° with the flat rings positioned against each other. This provides an excellent rotational movability.

The invention will now be further elucidated with reference to the drawings, which

in Figure 1A or 1B, respectively, show a first embodiment of the spring according to the invention in side view and exploded view;

in Figures 2A and 2B show a second embodiment of the spring according to the invention in side view and in exploded view; and

in Figure 3, schematically show a first embodiment of the endoscope according to the invention;

in Figure 4, schematically show a second embodiment of the endoscope according to the invention in a non-operational position;

in Figure 5, schematically show the endoscope according to Figure 4, in an operational position; and

in Figure 6, show an exploded view of a plurality of plate spring assemblies.

Identical reference numbers used in the figures indicate similar parts.

Referring first to the Figures 1 and 2, reference number 1 depicts the spring according to the invention, formed by a chain of a series of closed elements 2 that are flexible. These closed flexible elements are also

clearly shown in the Figures 1B and 2B. The elements 2 are at least partly 2 coupled in groups of two adjacent elements. This is clearly shown both in Figure 1A and Figure 2A. Figure 1A or 1B, respectively, relates to the embodiment wherein each pair of two adjacent elements 2 in the series is coupled at a position that albeit predetermined, is a different position to that of a neighbouring pair. This is especially clearly depicted in Figure 1B, which clearly visualizes the different orientation of the coupling position between two adjacent elements 2. The result is a spring as shown in Figure 1A, having a virtually uniform distribution as regards the flexibility and flexural stiffness in directions transversely to the longitudinal direction of the spring.

The Figures 2A and 2B show a second embodiment in which each pair of two adjacent elements 2 in the series is also coupled at a predetermined position, but with respect to a neighbouring pair of elements 2, always the same position. This is clearly illustrated in Figure 2A. The spring according to this embodiment consequently has relatively little flexural stiffness when the spring is loaded perpendicularly to the longitudinal direction and in the direction of the coupling positions, as indicated with the arrow A in Figure 2A. In contrast, in a direction perpendicular thereto, as indicated with the arrow B, the spring 1 has a relatively high degree of flexural stiffness. The embodiments shown in the Figures 1A and 1B, as well as the embodiments shown in the Figures 2A and 2B, however, share the characteristic of the spring having a very high degree of torsional stiffness.

The Figures 1A, 1B, 2A and 2B further show that each of the elements 2 has a central opening 3 defined by a rim 4 of the element 2. The Figures 1A to 2B further show that the rim 4 of the elements 2 is provided with feed-through openings 5 suitable for feeding a traction wire through.

The spring 1 is further embodied such that the elements are formed as rings. It should be remarked that

other forms are also possible, such as square, triangular or polygonal plates. One ring 2', for example, is completely flat. Coupled to this flat ring 2' is at least one ring comprising at least one first bent rim portion 2'' coupled with the flat ring 2'. The ring with this first bent rim portion 2'' preferably has a second bent rim portion 2''' diametrically opposite the first bent rim portion 2'' of that ring. This second bent rim portion 2''' is subsequently coupled with a bent rim portion of an identically embodied further ring, as can be clearly seen from the Figures 1 and 2.

Figure 3 shows a first embodiment of the endoscope according to the invention. Said endoscope is indicated with reference number 6, and comprises an endoscope shaft 7, a proximally positioned control handle 8, and a distally positioned camera 9. The camera 9 is coupled with the endoscope shaft 7 via the spring 1 according to the invention, and to allow operation of the camera 9 by means of the control handle 8, a traction wire 10 is provided which extends through the endoscope shaft 7 and is connected for one thing with the control handle 8, and for another thing with the distal end of the spring 1. The spring 1 used in the endoscope 6 is identical to the embodiment shown in the Figures 2A and 2B, that is to say the spring having little flexural stiffness in a predetermined direction perpendicular to the longitudinal direction of the spring 1. As shown in the Figures 2A and 2B, the spring according to this embodiment is at a position corresponding with the flexural stiffness characteristics of said spring provided with feed-through openings 5 for traction wires. In the embodiment of the endoscope shown in Figure 3 wherein the spring 1 is applied, one traction wire 11 is shorter, so that the spring is continuously loaded at one side.

Apart from the above-discussed advantages of the spring 1 according to the invention, there is the additional advantage that in the totally loaded condition the spring is very flat and that, for example, in the applica-

tion depicted in Figure 3, the spring has a very small radius. In the described application of the endoscope this is a very important and useful characteristic with respect to the realization of movement parallax.

With further reference to the Figures 4 and 5, a second embodiment of the endoscope 6 according to the invention is shown. Figure 4 or 5, respectively, shows the endoscope according to the invention in a non-operational position and in an operational position. Reference number 1, 1' indicate the spring according to the invention comprised in the endoscope, formed by linking a series of closed elements 2 that are flexible. This spring is also clearly shown in an exploded view in Figure 6. The elements 2 are at least partly coupled with adjacent elements 2. This is clearly illustrated in Figure 3.

Figures 6 further shows that each of the elements 2 has a central opening 3 defined by a rim 4 of the element 2. Figure 6 further shows that feed-through openings 5 are provided in the rim 4 of the elements 2, suitable for traction wires being passed through.

The spring 1 is further embodied such that the elements are formed as rings. It should be remarked that other forms are also possible, such as square, triangular or polygonal plates.

As is clearly shown in Figure 6, a plurality of spring assemblies (15) is positioned adjacent each other. The terminal elements of each assembly are embodied as flat rings. The other elements each have two bent rims positioned diametrically opposite to each other.

With reference once more to Figures 4 and 5, it is shown that the endoscope 6 and the endoscope shaft 7 comprise a proximally placed control handle 8, and a distally placed camera (not shown in the Figures). The camera 6 is coupled to the endoscope shaft 7 via the spring 1, and to allow the operation of the camera by means of the control handle, traction wires 10 are provided that are passed through the endoscope shaft 7 (indicated by broken lines) and which are connected for one thing with a

slidable element 13 located in the control handle 8, and for another thing with the distal end of the spring 1. The spring 1 used in the endoscope 6 of Figures 4 and 5, is identical to the embodiment shown in Figure 6.

The control handle 8 shown in Figures 4 and 5 comprises an external housing 12 and located therein the aforementioned slidable element 13. The slidable element 13 is connected by four traction wires with the distal end of the spring 1, at the distal end of the endoscope 6. Between the control handle 8 and the endoscope shaft 7 a second spring 1′ according to the invention is placed. This ensures correct guidance of the traction wires 10.

By means of a compensating spring 14, which may be the usual spiral spring or any other suitable spring, the slidable element 13 is pushed to the proximal end of the control handle. By choosing the compensation spring 14 with a sufficiently high spring tension, the springs 1, 1′ according to the invention will in a non-operational position be completely compressed, as shown in the Figures 4 and 5. Figure 5 clearly shows that when bending the control handle 8 to an angle ß in relation to the endoscope shaft, the distal end to which the camera is mounted, will adjust to the same angle. The lower traction wire 10 shown in Figure 5 is pulled, causing the compensating spring 14 to be compressed. The top traction wire veers, causing the distal end to adjust over a same angle in relation to the shaft. In this construction it is possible to rotate the distal end with the camera mounted thereon over 360° by rotating the control handle over a corresponding angle.

The invention also relates to an endoscope wherein the compensating spring 14 is located in the endoscope shaft 7. In this case it may be necessary, for example, for the endoscope shaft 7 to be able to telescope, allowing the same by the action of the compensating spring 14 to extend or to collapse.

Apart from the above discussed advantages of the spring 1, 1′ according to the invention, there is a further advantage that in the non-operational condition (Fig-

ure 4) the spring is very flat and that the same has a very small radius, as is shown in Figure 5. This is an important and useful characteristic, especially in the described application of the endoscope, with respect to the realization of movement parallax.

As mentioned above, the invention also relates to a flexible drill, provided with a spring of the abovementioned kind that is suitable for carrying out drilling operations at an angle. This occurs in particular in geological formations.

Finally, the invention is embodied in a coupling between two (driving) shafts placed at an angle in relation to each other, comprising a spring of the kind described above.

CLAIMS

1. A spring (1), **characterized** by a chain of a series of closed, flexible elements (2), of which always a pair of two adjacent elements (2) from the series are partly connected with each other.

2. A spring according to claim 1, **characterized** in that each pair of two adjacent elements (2) in the series of elements is coupled at a predetermined and in relation to a neighbouring pair of elements, different position (2).

3. A spring according to claim 1, **characterized** in that each pair of two adjacent elements (2) in the series of elements is coupled at a predetermined, and with respect to a neighbouring pair of elements(2), identical position.

4. A spring according to one of the claims 1-3, **characterized** in that each of the elements (2) has a central opening (3), which is defined by the rim (4) of the element (2).

5. A spring according to claim 4, **characterized** in that feed-through openings (5) are provided in the rim (4) of the elements (2), that are suitable for a traction wire to be passed through.

6. A spring according to one of the preceding claims, **characterized** in that the elements are rings of which at least one is completely flat, and that adjacent to said flat ring (2') there is at least one ring comprising at least one first bent rim portion (2'') coupled with the flat ring (2').

7. A spring according to claim 6, **characterized** in that the ring adjacent the flat ring with a first bent rim portion (2'') has a second bent rim portion (2''') diametrically opposite the first bent rim portion (2'') of that ring, and that this second bent rim portion of that ring

is coupled with a bent rim portion of an identically embodied further ring.

8. A spring according to one of the claims 1-7, **characterized** in that the same is fabricated from a rod or tube of spring steel, with regularly distributed grooves being applied over the surface of the rod or tube.

9. An endoscope (6) comprising an endoscope shaft (7), a proximally positioned control handle, and a distally positioned camera (9), **characterized** in that the camera (9) is coupled with the endoscope shaft (7) via a first spring (1) in accordance with one of the claims 1-8, and that at least one traction wire (10) extends through the endoscope (7) and is connected for one thing with the control means, and for another thing with the distal end of the spring (1).

10. An endoscope (6) according to claim 9, **characterized** in that at least three traction wires (10) are passed through the endoscope shaft (7), being coupled for one thing with a sliding element (13) located in the control handle (8) and for another thing with the distally positioned end of the first spring (1), and that a compensating spring (14) exerts a force on the sliding element (13) to ensure that in a non-operational position the first spring (1) is compressed.

11. An endoscope (6) according to claim 8, 9 or 10, **characterized** in that a second spring (1') according to one of the claims 1-8 is provided between the endoscope shaft (7) and the control handle (8).

12. An endoscope (6) according to one of the claims 8-11, **characterized** in that the traction wires are passed through the openings (5) provided in the elements of the springs (1, 1').

13. An endoscope (6) according to one of the claims 8-12, **characterized** in that the springs (1, 1') are comprised of substantially identical spring assemblies which are always combined rotating over their longitudinal axis, such that the openings (5) provided in the spring elements are aligned with each other.

14. A flexible drill, provided with a spring according to one of the claims 1-8.

15. A coupling between two axes, comprising a spring according to one of the claims 1-8.

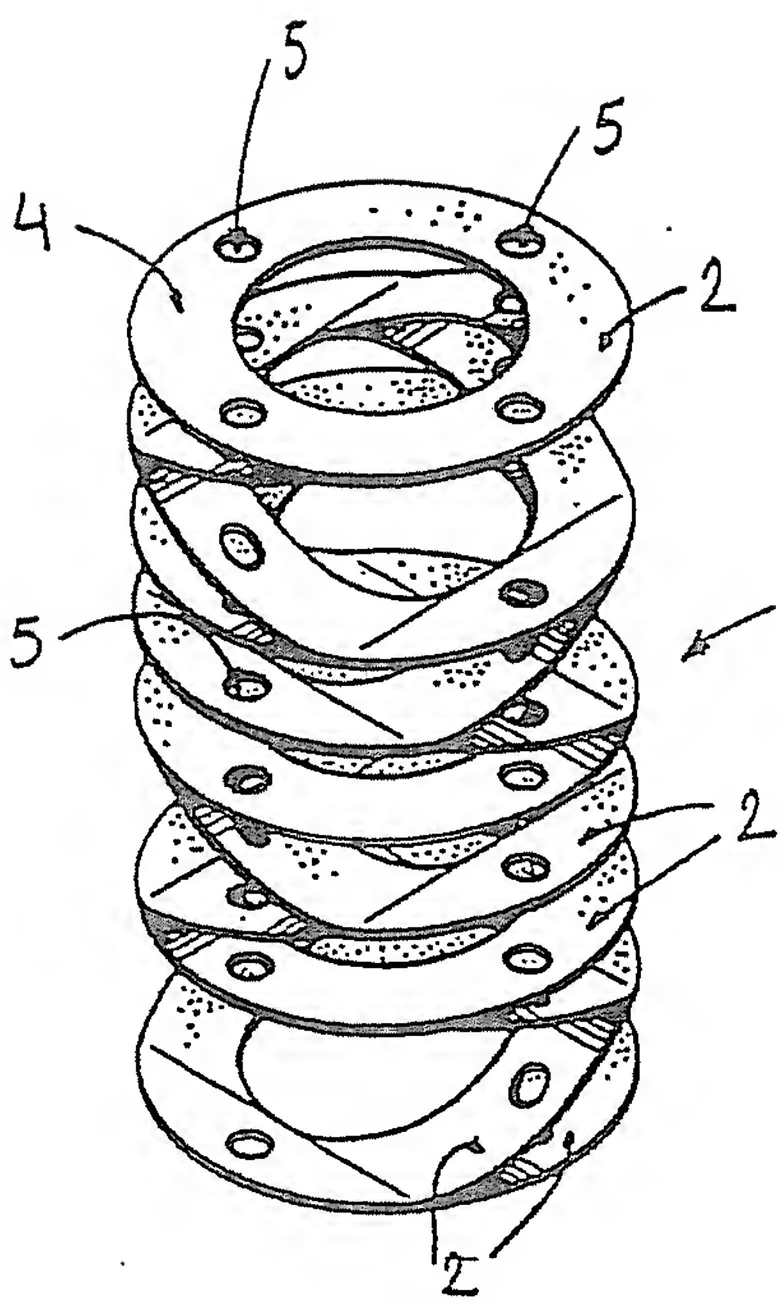

FIG. 1A

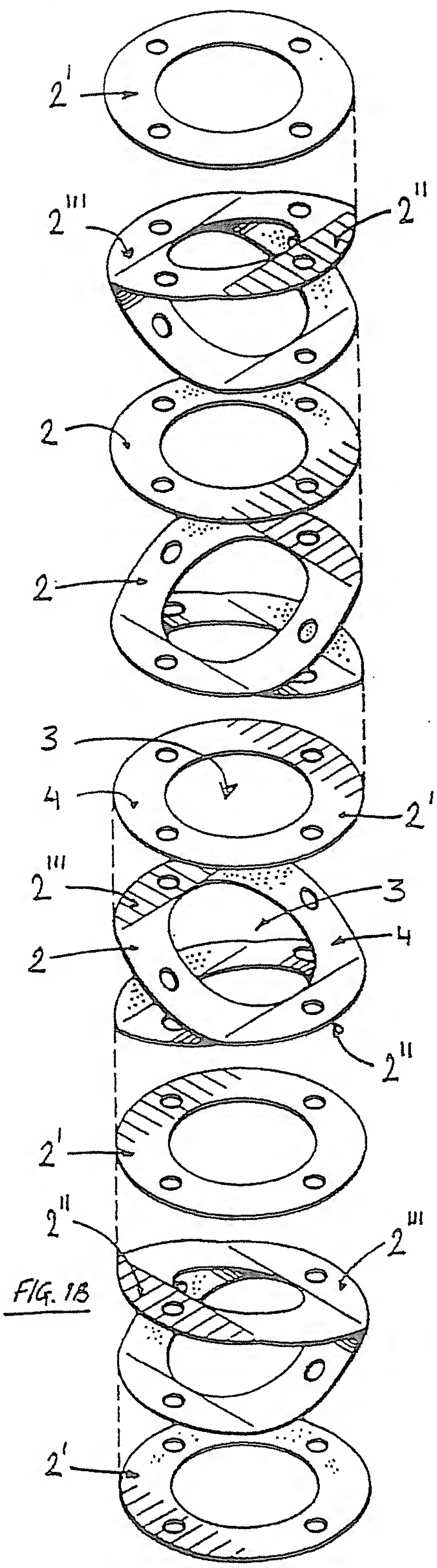

FIG. 1B

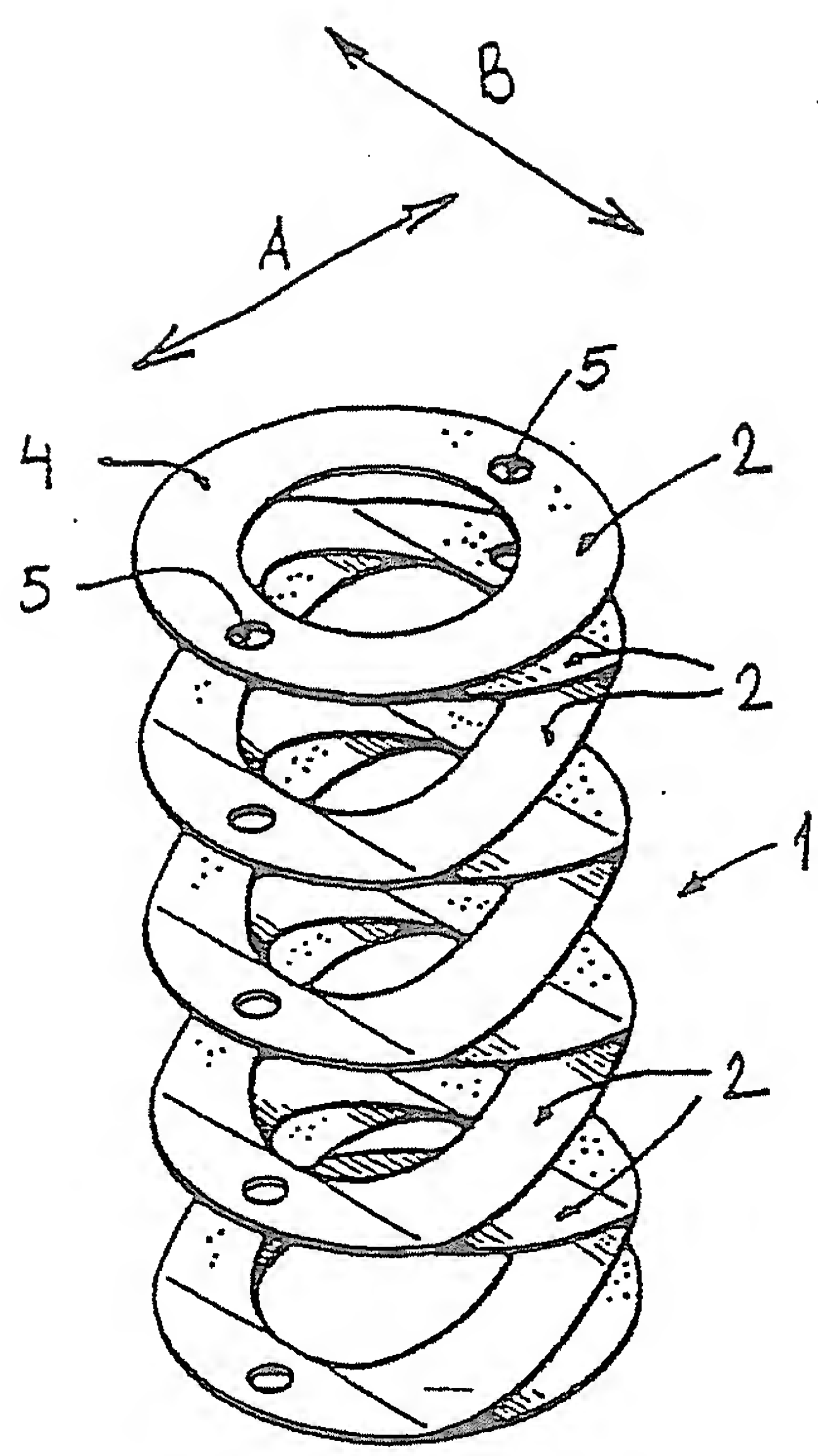

FIG. 2A

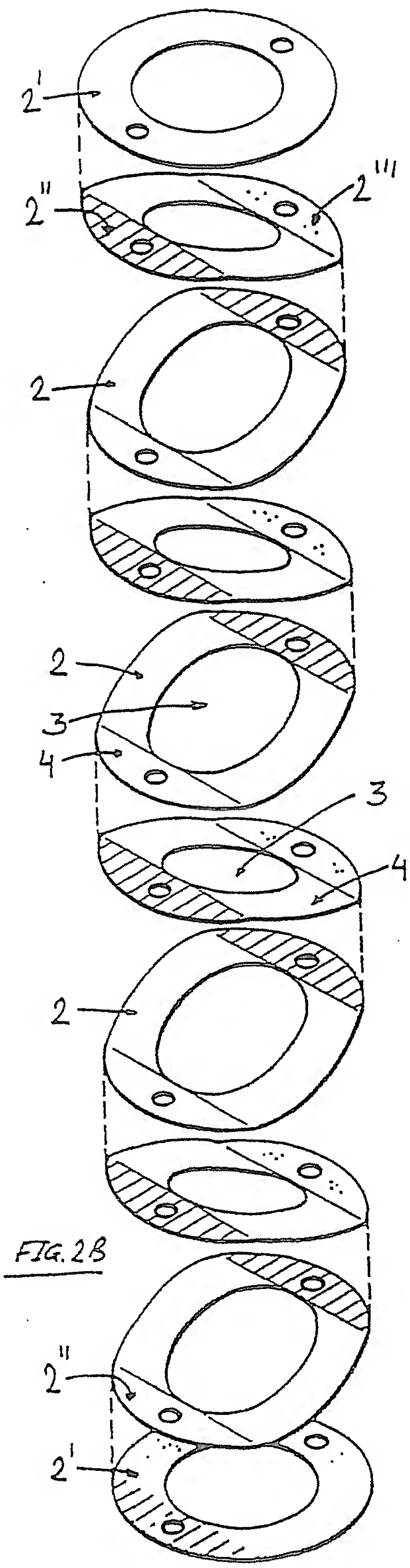

FIG. 2B

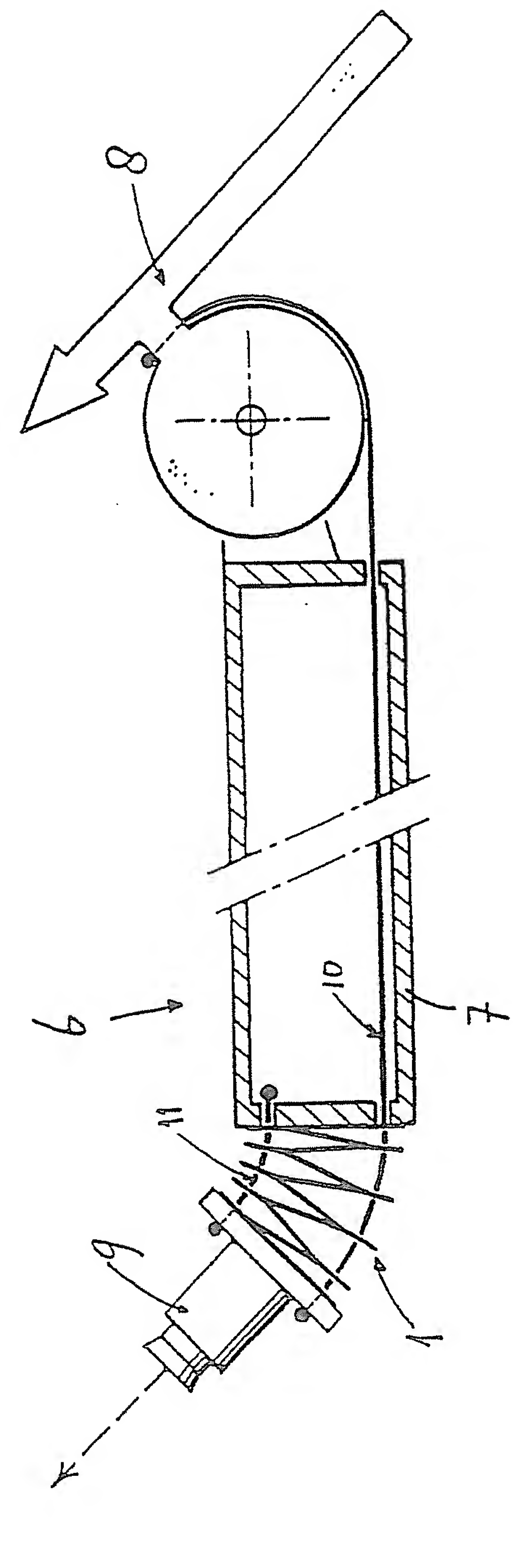

FIG. 3

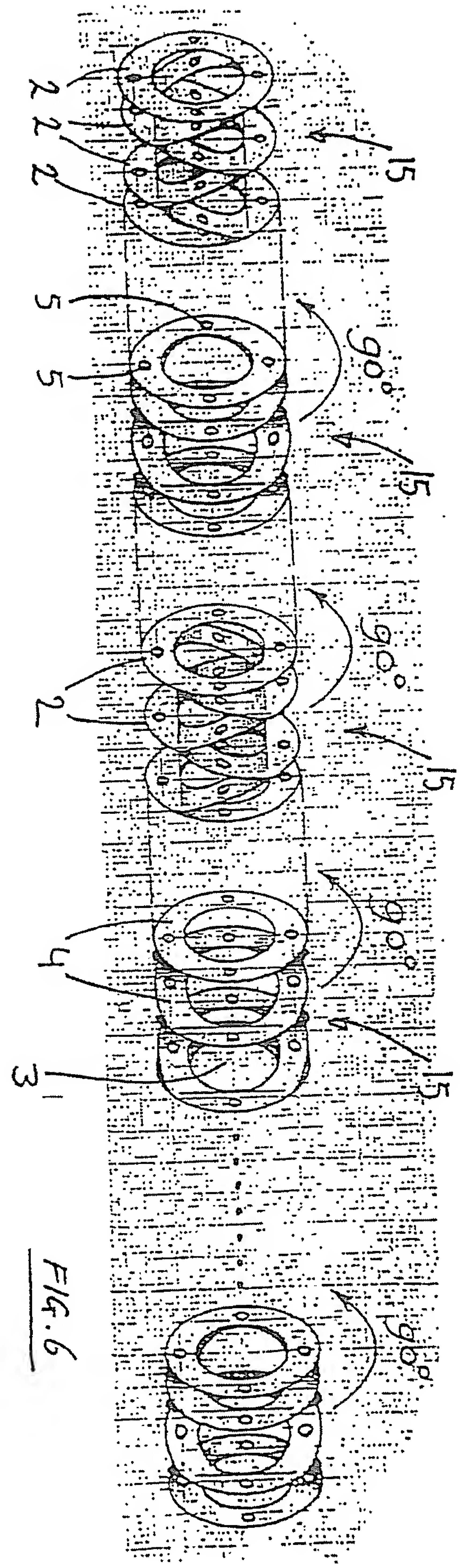

FIG. 6

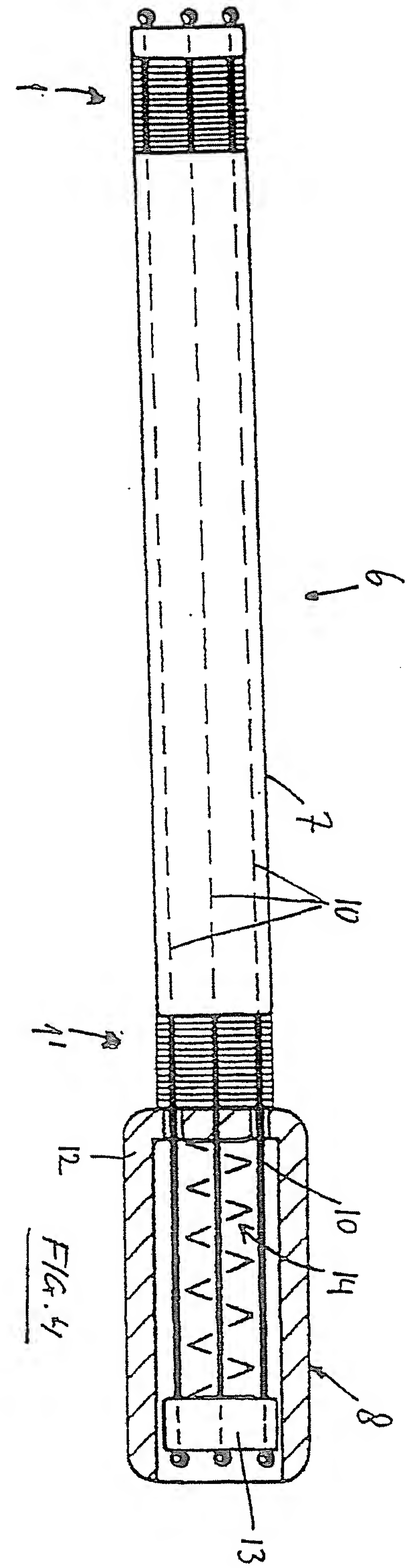

FIG. 4

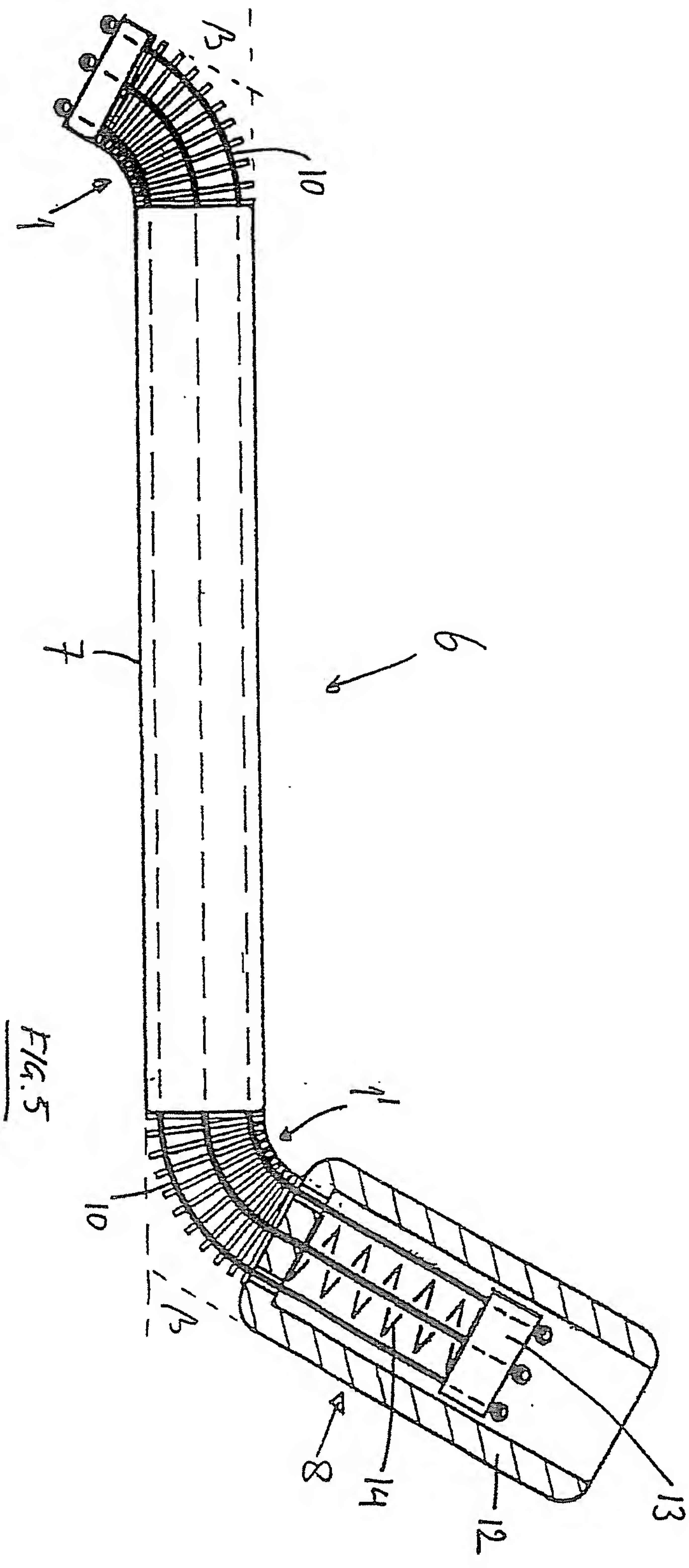

FIG. 5

INTERNATIONAL SEARCH REPORT

Inte	Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61B1/005 A61M25/01 F16F1/32 F16F1/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61B A61M F16F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	M. GREENHILL: "NEW OPTIONS FOR WAVE SPRINGS" MACHINE DESIGN, March 1982 (1982-03), pages 89-92, XP002019961 the whole document ---	1-9
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A	US 5 176 126 A (T. CHIKAMA) 5 January 1993 (1993-01-05) abstract; figures 1-10 ---	1,9

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
1 November 2001	07/11/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Hunt, B

INTERNATIONAL SEARCH REPORT

Inter Application No
PC.,... 01/00552

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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